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Discrepancies between Self-reported Smoking and Carboxyhemoglobin: An Analysis of the Second National Health and Nutrition Survey

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ABSTRACT

Environmental, self report, and demographic factors mediated the relationship between self-reported cigarette smoking and carboxyhemoglobin among 2114 smokers and 3918 nonsmokers. Self-reported nonsmokers with carboxyhemoglobin levels between 2% and 3% were more likely to be self-reported ex-smokers, to live in a larger community, and to be younger, less educated, and male than were self-reported nonsmokers with carboxyhemoglobin levels of less than 2%. Self-reported nonsmokers with strong evidence of cigarette consumption (carboxyhemoglobin level > 3%) were more likely to be self-reported ex-smokers, younger, less educated, and non-White than were nonsmokers with carboxyhemoglobin levels of less than 2%. (*Am J Public Health.* 1992;82:1026–1029)

Introduction

Because of uncertainties inherent in measurement of smoking behavior using self-report,[1] biochemical measures are frequently used to validate reported smoking exposure. Although cotinine is often the preferred biochemical measure of smoking exposure,[2] blood carbon monoxide concentration is useful in many circumstances. It is less expensive to measure and can discriminate smokeless tobacco products from cigarette, pipe, and cigar smoking. It can also verify smoking cessation in treatment programs using nicotine replacement. Carbon monoxide is particularly useful in establishing health risks of smoking because of its strong relationship with cardiovascular disease.[3]

The current study sought to investigate factors associated with discrepancies between self-reported smoking status and carboxyhemoglobin levels. By identifying circumstances under which carboxyhemoglobin levels and self-reported smoking status do not agree, investigators can make more informed judgments about the validity of these measures of smoking and the associations between smoking and morbidity when carboxyhemoglobin is used.

Methods

The study sample consisted of 6032 participants from the Second National Health and Nutrition Examination Survey (NHANES II), aged 18 to 74 years, who completed a carboxyhemoglobin assessment. Detailed description of the survey methodology for NHANES II is available.[4] Self-reported smoking status was ascertained by asking participants whether they currently smoked cigarettes, how many they smoked on average, and whether they smoked cigars or pipes. Subjects reporting no current use of tobacco products were considered nonsmokers, while those smoking pipes or cigars were excluded. Carboxyhemoglobin concentrations, determined by spectrographic assay,[5] are expressed as percentages of total hemoglobin combined with carbon monoxide. Statistical analyses were performed using the Statistical Analysis System.[6] Collinearity diagnostics, as discussed by Hosmer and Lemeshow,[7] did not reveal unreliable estimates.

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Results

Table 1 provides a demographic description of the study sample. Although the distributions overlapped, the average carboxyhemoglobin level of smokers was higher than that of nonsmokers. Based on its discriminant ability in previous investigations,[8,9] a carboxyhemoglobin level of 2% or more was used to identify smokers. Table 2 shows the relationship between self-reported smoking and elevated carboxyhemoglobin levels. Using carboxyhemoglobin as the standard, sensitivity and specificity were 84.8% and 95.8%, respectively, while the positive predictive value of carboxyhemoglobin was 91.5%. Two thirds of discrepancies involved subjects who reported that they smoked but had carboxyhemoglobin levels of less than 2%.

Subjects who reported smoking but had carboxyhemoglobin levels of less than 2% were categorized on cigarette rate (i.e., <10 cigarettes per day or 10+ cigarettes per day). Logistic regression equations compared each of these subgroups with self-reported smokers having carboxyhemoglobin levels of 2% or more. The first analysis compared the low cigarette consumption group with the accordant carboxyhemoglobin group. The odds of misclassification (see Table 3) were higher for Whites and those with lower cigarette consumption. Subjects who had carboxyhemoglobin levels of less than 2% and smoked 10+ cigarettes per day were also compared with smokers with accordant carboxyhemoglobin levels (≥2%). The odds of having discrepant vs accordant carboxyhemoglobin levels were increased for Whites, men, and those with lower cigarette consumption and higher body mass.

Among self-reported nonsmokers, logistic regression analyses were performed to identify factors that discriminated discrepant vs accordant subjects. Because marginally elevated carboxyhemoglobin levels may result from passive exposure and large elevations are more likely due to cigarette exposure, two logistic regression analyses were conducted. In the first, predictors of accordance (i.e., carboxyhemoglobin level < 2%) vs marginal discrepancies (i.e., carboxyhemoglobin level between 2% and 3%) were evaluated. In the second analysis, predictors of accordance vs severe discrepancies (i.e., carboxyhemoglobin level > 3%) were assessed.

Predictors of marginal discrepancies are presented in Table 4. Male subjects were more likely to be misclassified as smokers (61% more at risk) than were female subjects. Also, misclassification decreased with advancing age and education. The strongest predictor was size of the community of residence. The odds of having marginally discrepant carboxyhemoglobin levels increased threefold from rural to large urban (>3 million) areas. Finally, self-reported ex-smokers were 55% more likely to have discrepant carboxyhemoglobin levels than were never smokers.

The second logistic regression compared self-reported nonsmokers with carboxyhemoglobin levels of more than 3% and those with carboxyhemoglobin levels of less than 2%. Those with strong evidence of cigarette consumption were 75% more likely to be reported ex-smokers and twice as likely to be non-White compared with accordant nonsmokers. As age and education increased, the odds of having discrepant vs accordant carboxyhemoglobin levels decreased.

TABLE 1—Demographic Characteristics of the Subject Sample

	Self-reported Nonsmokers (n = 3918)	Self-reported Smokers (n = 2114)
Sex, No. (%)		
Male	1583 (40)	1123 (53)
Female	2335 (60)	991 (47)
Race, No. (%)		
Black	402 (10)	298 (14)
White	3444 (88)	1778 (84)
Other	72 (2)	38 (2)
Education, No. (%)		
High school or less	2204 (75)	1416 (67)
Some college	1714 (25)	698 (33)
Age, y		
Mean (SD)	48.3 (18.43)	42.4 (16.61)
Range	18–74	18–74
Carboxyhemoglobin level		
Mean (SD)	0.90 (0.96)	4.55 (2.35)
Range	0.00–11.53	0.05–12.92
Body mass index, kg/m²		
Mean (SD)	25.79 (4.99)	24.62 (4.78)
Range	14.47–55.43	12.39–59.98
Size of community, No. (%)		
Rural	1411 (36)	720 (34)
Urban: 2500–999 999	1531 (39)	834 (39)
Urban: 1 million +	976 (25)	560 (26)

TABLE 2—Agreement of Self-reported Smoking Status and Carboxyhemoglobin Level

	Carboxyhemoglobin Level, No. (%)	
	< 2%	≥ 2%
Self-reported nonsmokers	3752 (95.8)	166 (4.2)
Self-reported smokers	321 (15.2)	1793 (84.8)

Discussion

The agreement between self-reported smoking and carboxyhemoglobin level of 91.9% is consistent with previous studies not using bogus pipeline or pipeline procedures to increase the validity of self-reports.[9,10] Discrepancies between self-reports and carboxyhemoglobin levels were not random but were predicted by demographic and smoking-related variables. The conundrum of these discrepancies is to differentiate falsification of self-reported smoking from failure of carboxyhemoglobin measures.

Because of this uncertainty, the role of biochemical verification in general surveys of smoking behavior remains controversial. Some data suggest increasing falsification in general surveys,[11,12] while other studies conclude that self-reports are superior to biochemical measures.[13] Self-reports of smoking in cessation pro-

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TABLE 3—Predictors of Discrepancies in Self-reported Smokers

	< 10 Cigarettes per Day vs Accordant Carboxyhemoglobin Level (≥ 2%)[a]				≥ 10 Cigarettes per Day vs Accordant Carboxyhemoglobin Level (≥ 2%)[b]			
	Odds Ratio	(95% CI)	χ^2	P	Odds Ratio	(95% CI)	χ^2	P
No. of cigarettes (per 5 cigarettes/day)	14.78	(9.53, 22.91)	145.02	<.001	1.17	(1.08, 1.27)	13.77	<.001
Body mass, kg/m^2	0.95	(0.91, 1.00)	3.24	.072	0.95	(0.92, 0.98)	11.03	<.001
Race (0 = White, 1 = non-White)	3.16	(1.64, 6.11)	11.75	<.001	2.80	(1.58, 4.88)	12.71	<.001
Sex (0 = male, 1 = female)	0.83	(0.49, 1.41)	0.47	.491	0.68	(0.49, 0.93)	5.67	.017
Age (per 15 y)	0.96	(0.76, 1.22)	0.12	.729	0.94	(0.81, 1.09)	0.60	.437
Education (per 4 y)	0.79	(0.57, 1.10)	2.00	.157	0.90	(0.72, 1.12)	0.86	.354
Size of community (rural to 3 million +)	1.06	(0.95, 1.17)	1.06	.304	0.94	(0.89, 1.00)	3.82	.051

[a]n = 1912 (136 discrepancies).
[b]n = 1960 (176 discrepancies).

TABLE 4—Predictors of Discrepancies in Self-reported Nonsmokers

	Accordant (< 2%) vs Marginally Elevated Carboxyhemoglobin Level (2% -3%)[a]				Accordant (< 2%) vs Highly Elevated Carboxyhemoglobin Level (> 3%)[b]			
	Odds Ratio	(95% CI)	χ^2	P	Odds Ratio	(95% CI)	χ^2	P
Ex-smoker (0 = yes, 1 = no)	1.55	(0.98, 2.46)	3.48	.062	1.74	(1.07, 2.85)	4.92	.026
Race (0 = White, 1 = non-White)	0.94	(0.50, 1.76)	0.04	.846	2.00	(1.10, 3.66)	5.13	.023
Sex (0 = male, 1 = female)	0.62	(0.39, 0.97)	4.38	.036	0.71	(0.44, 1.15)	1.96	.161
Age (per 15 y)	0.78	(0.64, 0.94)	6.60	.010	0.69	(0.56, 0.85)	12.60	.001
Education (per 4 y)	0.74	(0.57, 0.95)	5.74	.017	0.73	(0.56, 0.96)	5.00	.025
Size of community (rural to 3 million +)	3.19	(1.64, 6.18)	11.80	.001	0.87	(0.47, 1.60)	0.13	.715

[a]n = 3810 (87 discrepancies).
[b]n = 3800 (77 discrepancies).

grams are inaccurate[14,15] as a result of interest in pleasing experimenters, experimental demand, and social pressures against smoking. Although falsification is reduced by bogus pipeline procedures[16] (i.e., subjects believe their reports will be biochemically validated), actual biochemical verifications are often recommended. Since, as the current findings suggest, carboxyhemoglobin level failed to predict the smoking status of certain individuals, blanket recommendations for carboxyhemoglobin verification are premature until the sources of disagreements between self-reports and carboxyhemoglobin levels are better understood. At present, the need for verification should be based on the characteristics of the target sample or cohort and the circumstances surrounding the collection of data.

Disagreement was highest (15.2%) in subjects who reported that they smoked but had carboxyhemoglobin levels of less than 2%. Discrepancies were predicted by the dosing variables of cigarettes per day and body mass, as well as race and sex. Because unmeasured smoking topography may differ by race and sex, it is difficult to distinguish physiological differences in carbon monoxide absorption and elimination from carbon monoxide exposure variables. However, regardless of causative factors, using carboxyhemoglobin level as the sole criterion of smoking for these individuals would bias estimates of disease risk related to smoking and the efficacy of treatment programs. Self-reports for these individuals are preferred over carboxyhemoglobin levels alone because the failure of carboxyhemoglobin is greater than that of self-reports in establishing smoking.

Self-reported nonsmokers with carboxyhemoglobin levels greater than 3% are most likely misreporting smoking because large elevations in carboxyhemoglobin levels attributed to carbon monoxide emissions are uncommon.[17] Self-reported ex-smokers were likely to misreport smoking status, perhaps because of the social pressures of participating in a health examination survey. They may intend to quit smoking or have relapsed recently and want to claim ex-smoking status. Likewise, younger, non-White, and less-educated subjects misreported at a higher rate than their respective counterparts. These individuals may be responsive to perceived demand by interviewers or reticent to report smoking habits. Inhalation of carbon monoxide from other organic substances or occupational sources may be responsible for some carboxyhemoglobin elevations. Carbon monoxide in marijuana smoke reportedly increases false-positives.[18]

Finally, that marginal elevations in carboxyhemoglobin levels among self-reported nonsmokers may be due to passive exposure to carbon monoxide is supported by the finding that size of community predicted these marginal elevations. Marginal elevations were also predicted by being non-White and poorer educated, which may, in part, be explained by carbon monoxide emission in the home environment and occupational exposures[17] or a higher incidence of hemolytic anemia[19] in these individuals. □

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Recall of AIDS Public Service Announcements and Their Impact on the Ranking of AIDS as a National Problem

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ABSTRACT

The efficacy of two public service announcements from Phase V of the "America Responds to AIDS" (ARTA) campaign was assessed at two sites. Participants were randomly assigned to view a local news program, one with an ARTA public service announcement appearing six times and the other with no AIDS public service announcements. During telephone interviews with 907 participants 1 to 3 nights after viewing, 21% at Site A and 59% at Site B could correctly recall the ARTA public service announcements. Absolute mentions of AIDS as an important national issue increased. (*Am J Public Health.* 1992;82:1029–1032)

Introduction

The evaluation of finished public health media material is often recommended for public health campaigns.[1–3] In late May and early June of 1990, the National AIDS Information and Education Program of the Centers for Disease Control ran a field study to test the short-term efficacy of two television public service announcements regarding human immunodeficiency virus (HIV) and acquired immunodeficiency syndrome (AIDS) from Phase V of the "America Responds to AIDS" (ARTA) campaign. The two public service announcements were "Wonderful World," which shows children playing in a field and a little girl talking about wanting to grow up in a better world, and "Sofa," which shows a young couple on a sofa kissing while an an-

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